COMPUTER AIDED DESIGN AND STRUCTURAL ANALYSIS OF A RIM

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ABSTRACT

Automobile wheel is an important component in vehicles to support the vehicle weight and maintain the contact between the vehicle body and road. Automotive wheels have evolved over the decades using materials from steels to aluminum and magnesium alloys. Aluminum wheels have gain popularity over steel wheels because they have less weight, better cosmetic appearance, and higher thermal conductivity for faster dissipation of heat from brakes.

A rim is subject to mainly radial load and inflation pressure. The radial load is exerted on the rim as a vertical reaction force by road surface on four tires to balance the weight of a car. The radial load is applied to the rim at the bead seats with the tire, following a cosine function distribution around the contact area. The tire air pressure is applied directly on the rim at its outer side and indirectly at the rim flange. This project studied the influence of the radial load and the tire inflation pressure on the stress and displacement distribution in the wheel rim. A computer aided design model of an aluminum alloy wheel rim is analyzed using ANSYS. The geometrical parameters of the rim is further optimized to reduce weight

INTRODUCTION

All vehicle requires the use of Rim upon which the tire is mounted. In the case of a tubeless tire, we need a single-piece rim with a safety rim profile, which helps in keeping the tire bead firm on the Rim under all conditions. When designing a rim for an automobile, we need to consider certain geometrical parameters which directly impacts the comforts of driving. As rim is where the tire resides and also supports the tire shape, it plays a vital role. So designing a Rim is very important. The Rim manufacturing is done in many ways, one such way is hot forging and then performing NC machining to obtain the dimensional parameters.

Steel and light alloy are the foremost materials used in a wheel rim however some composite materials together with glass-fiber are being used for special wheels

a) Wire Spoke Wheel
b) Steel Disc Wheel

This is a rim which practices the steel-made rim and the wheel into one by joining (welding), and it is used mainly for passenger vehicles especially original equipment tires.

c) Light Alloy Wheel

These wheels are based on the use of light metals, such as aluminum and magnesium has come to be popular in the market. This wheel rapidly become standard for the original equipment vehicle in Europe in 1960's and for the replacement tire in United States in 1970's.

DESIGN DESCRIPTION

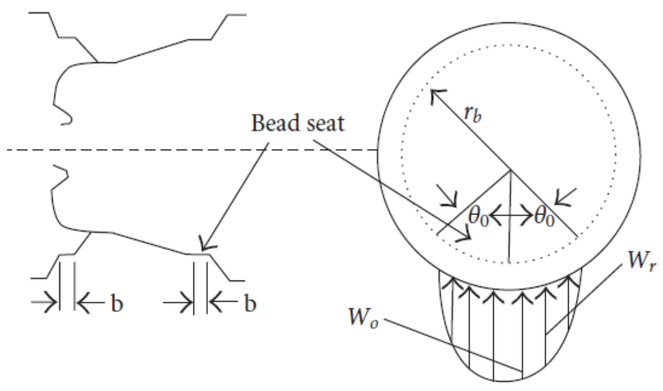
Diameter of the Rim : 17 inches
Thickness of the Rim : 7.5 inches
Bolt hole Inner diameter Maximum – 0.08 inches
Bolt hole Outer diameter Minimum – 0.16 inches

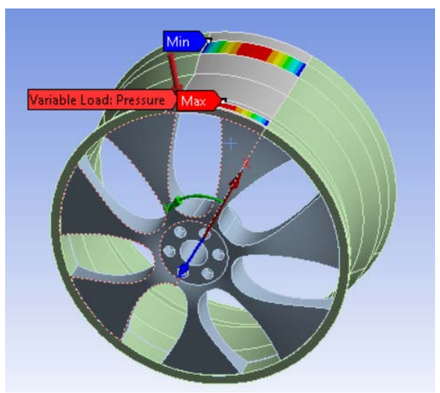
LOAD CONDITIONS

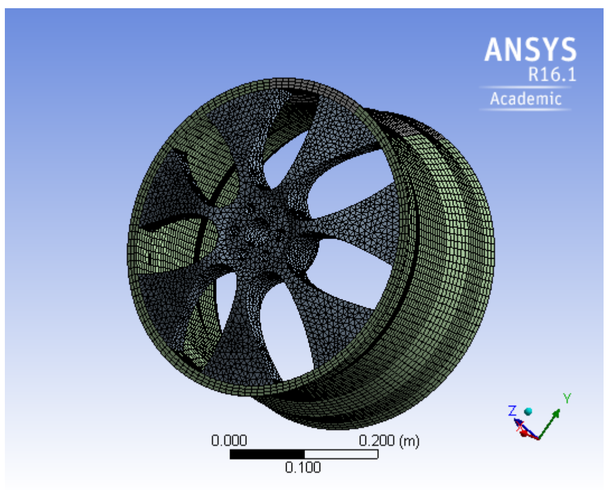
The radial load is exerted on the rim by tires to balance the total weight of the car. When the car is in motion, the radial load become cyclic and can cause fatigue failure of the structure. The radial load is applied to the wheel at the bead seats with the tire. The distributed pressure is assumed to have a cosine function distribution at the contact.

$$W_r = W_0 \cos\left(\frac{\pi}{2}\frac{\theta}{\theta_0}\right) \qquad F_r = \int_{-\theta_0}^{\theta_0} 2br_b W_r \, d\theta$$

Assuming the radial load is distributed around 40° to support a radial load of 4350 N.





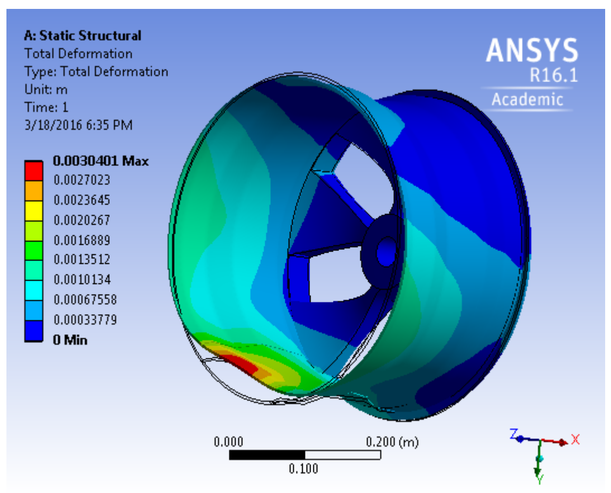


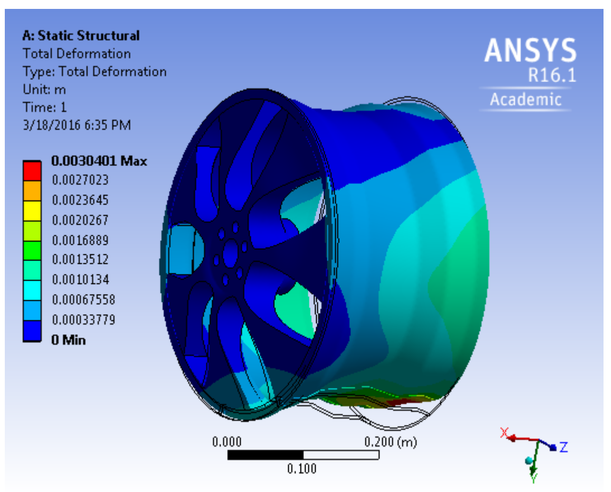
MATERIAL AND ITS PROPERTIES

Material : Aluminum Alloy
Properties
Density : 2770 kg/in^3
Young's Modulus: 71 GPa
Poisson's Ratio : 0.33
Tensile Yield Strength : 280 MPa
Yield Strength : 310 MPa

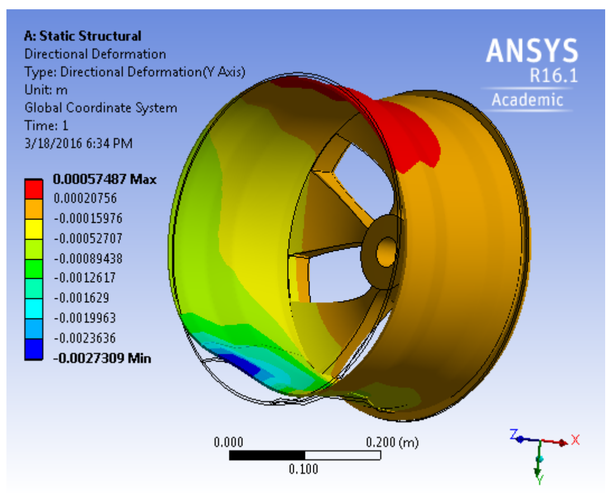
STRUTURAL ANALYSIS

TOTAL DEFORMATION

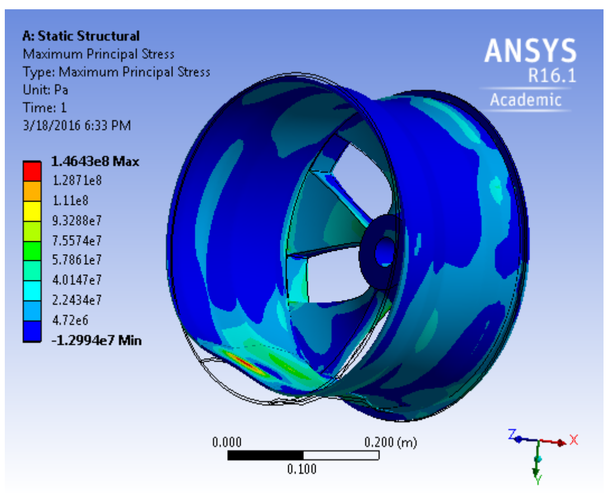




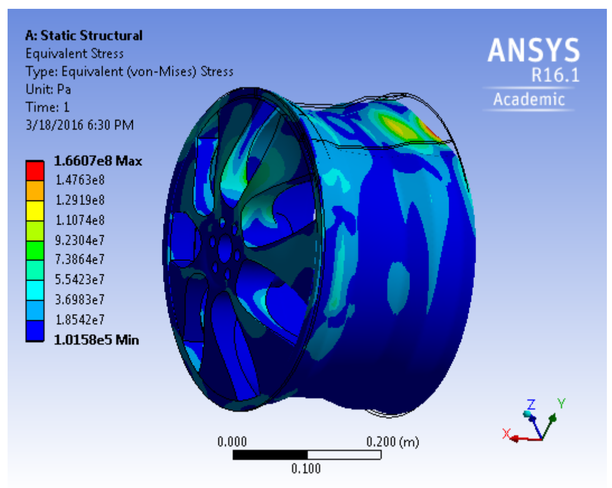
VERTICAL DISPLACEMENT



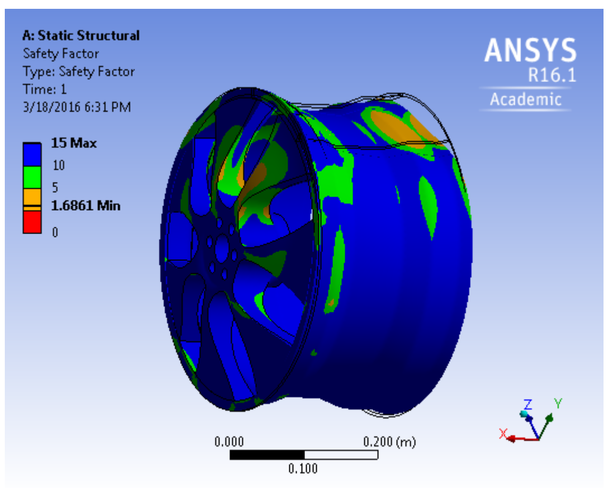
MAXIMUM PRINCIPAL STRESS



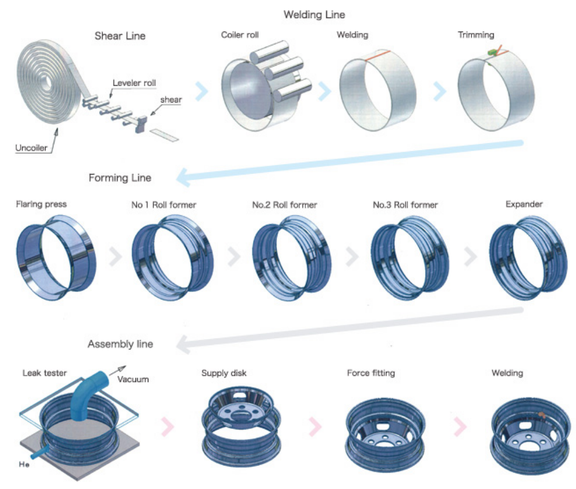
VON-MISESS STRESS



FACTOR OF SAFETY



MANUFACTURING PROCESS



FUTURE IMPROVEMENTS

In the above proposed work, only radial static load on the wheel rim is considered. This can be extended by considering all the other load conditions such as during braking and cornering, and also by performing a transient analysis for finding the fatigue life.

CONCLUSION

An rim was designed to withstand the given load conditions. Assuming a cosine distribution of static load at the rim and tire contact surfaces, the rim is analyzed using ANSYS. The maximum deformation is found to be at the vertical contact point near the inboard side. The minimum safety factor is 1.69. The deformation near the disk and spoke is small. The rim design parameters can be further optimized to achieve higher safety factor in the inboard side and reduce weight in the disk spoke side.

REFERENCE

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- P. Reipert, "Optimization of an extremely light cast aluminium alloy wheel rim," *International Journal of Vehicle Design*, vol. 6,no. 4-5, pp. 509–513, 1985.